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## **2013 Occupant Protection Risk Standing Review Panel Status Review**

**Statement of Task for:**  
*The Risk of Injury from Dynamic Loads*

### **Comments to the Human Research Program, Chief Scientist**

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2013 Occupant Protection (OP) Risk Standing Review Panel (SRP) Status Review  
WebEx/teleconference Participants:

**SRP Members:**

Frank Pintar, Ph.D. (chair) – Medical College of Wisconsin  
Paul Ivancic, Ph.D. – Yale University School of Medicine  
Michael Kleinberger, Ph.D. – Johns Hopkins University  
Daniel Nicolella, Ph.D. – Southwest Research Institute

**NASA Johnson Space Center (JSC):**

Pam Baskin, B.A.  
Ronita Cromwell, Ph.D.  
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**NASA Headquarters (HQ):**

Bruce Hather, Ph.D.  
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**NASA Research and Education Support Services (NRESS):**

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On December 17, 2013, the OP Risk SRP, participants from the JSC, HQ, and NRESS participated in a WebEx/teleconference. The purpose of the call (as stated in the Statement of Task) was to allow the SRP members to:

1. Receive an update by the Human Research Program (HRP) Chief Scientist or Deputy Chief Scientist on the status of NASA's current and future exploration plans and the impact these will have on the HRP.
2. Receive an update on any changes within the HRP since the 2012 SRP meeting.
3. Receive an update by the Element or Project Scientist(s) on progress since the 2012 SRP meeting.
4. Participate in a discussion with the HRP Chief Scientist, Deputy Chief Scientist, and the Element regarding possible topics to be addressed at the next SRP meeting.

Based on the presentations and the discussion during the WebEx/teleconference, the SRP would like to relay the following information to Dr. Shelhamer, the HRP Chief Scientist.

General Comments:

- The SRP thought that the presentations were very organized and informative.
- On the Human Research Roadmap (HRR) the OP risk HRP Research Ratings seem to have changed to “controlled” and “acceptable” for near Earth orbit missions. During the 2012 SRP review, those were still coded as “insufficient data”. It seems that the exposure conditions for the nominal and off-nominal landings and takeoff are not even defined well, and therefore the SRP does not understand the coding of “controlled” and “acceptable”.
- Also, the integration of the OP risk with other risk areas such as bone fracture, degenerative tissue, osteoporosis, radiation exposure, and even inadequate nutrition should be emphasized. It is unknown how these other human conditions affect the strength and tolerance of the body to dynamic loads. The SRP thinks the integration of the scientific disciplines is key to understanding this.

Comments on the New Requirements:

- The SRP applauds the use of two different sizes of dummy. Most of the experience with the Hybrid-III is with the 50th Male, so the new recommendation may not benefit as greatly from past experience. The Hybrid III is less biofidelic than the Test device for Human Occupant Restraint (THOR). While it is reasonable to require interim testing using the Hybrid III, the SRP recommends that the OP group continue to work towards implementation of the THOR anthropomorphic test devices (ATD) and its associated computational models.
- It is assumed that the off-nominal requirements are higher than the nominal because the acceptable risk level is higher. There was some discussion of these differences during the December 17<sup>th</sup> WebEx/teleconference; please ensure that the different tolerance levels follow this presumed rationale. The Injury Assessment Reference Value's (IARV) for

Peak Lumbar Axial Compression seem a bit high to address very low probability of injury. Please provide the SRP with an adequate reference.

- The requirement for human testing is good, however the OP group mentioned that some injuries recently occurred during nominal take-off and landing conditions. The OP group should work towards reducing these injury risks prior to the human testing.
- When using the Hybrid-III in predominantly +Z loading conditions testing engineers should be aware of the difficulty in maintaining the integrity of the buttocks flesh. The flesh over the contact points is easily damaged with a minimal number of tests. This damage can alter the readings on the dummy accelerometers and load cells.

#### Comments on the Low Injury Risk Question:

- The SRP thinks obtaining confidence at low injury risk levels is probably best done with the use of living human subject evaluations. The OP group will be testing humans in a number of different evaluations. If the exposure levels are well defined, then any dummy or computational model can be evaluated against the same exposure levels to ensure low values and thus validate the use of the tool.
- The Neck Injury Criteria (Nij) criterion is used to assess neck injury which considers the axial load and sagittal bending moment. As discussed, the OP group will compute the three-dimensional loads. The SRP recommends considering development or implementation of a load-based injury criterion that incorporates the three-dimensional loads. The SRP also encourages the OP group to analyze displacements and consider displacement-based injury criteria. The SRP suggests data mining to determine whether direction-specific tolerances for injuries to brain tissue exist based upon computed head rotational accelerations.

#### Comments on the Multi-Axial Environment:

- Although there are limitations of both the Hybrid III and THOR for multi-axial events, the SRP thinks that THOR is still a better multi-axial dummy than the Hybrid-III (H3). Certainly if the computer finite element (FE) models of the THOR and H3 are found useful for this project, the designers could start by using the FE model to compare a multi-axial environment. If this is done, the SRP thinks it may be useful to include a few side impact criteria limits (such as chest compression) just to have some evaluation criteria.

#### Comments on the Inclusion of the Suit:

- The proposed use of FE models that include the suit is an adequate way to start addressing suit-related issues. Again, the SRP thinks the use of human subject testing results with and without suits should be used as soon as available to assist in validating the FE modeling efforts.
- In addition to validation of the computational model with the ATD test results, it is recommended to validate the computer model with some human experiments at lower, non-injurious, impact severities.

Comments on the inclusion of a Wide Range of Subjects:

- The SRP thinks using the extremes of the anthropometry and sex differences is a good way to start but the risk is that one particular end of the extreme will be dominant and drive the safety of your designs. Using initial testing of the Hybrid III, the OP group may more easily simulate take-off and landing conditions using a more complete range of dummies from the 5<sup>th</sup> through the 95<sup>th</sup> percentile for both males and females, as compared to the tests using THOR. Previously developed computational models of the Hybrid III family of dummies exist which could also be used.

Comments on the Extensibility of the Findings:

- The SRP suggests the OP group continue to collect as much data as possible for different test conditions using different occupants or different modeling tools to help evaluate new proposed designs. If the IARV's used in a given model are truly occupant based, they should be translatable to other vehicle designs. Sensitivity studies should inform how valid each tool is at the levels of exposure being evaluated.
- The SRP thinks the human testing results will likely be specific to the vehicle design, impact conditions, and subject anthropometrics. However the human response data will be valuable as partial validation of the computational models, which can be extended to other vehicle designs.